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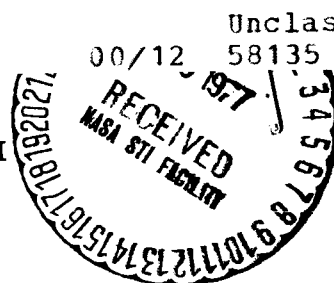
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LUNAR LOGISTIC SYSTEM  
VOLUME VII  
TESTING ASPECTS  
BY

AEROBALLISTICS DIVISION



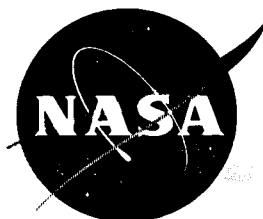
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LUNAR LOGISTIC SYSTEM  
VOLUME VII  
TESTING ASPECTS

By

J. L. Tidd  
B. Guyton  
L. S. Yarbrough

ABSTRACT

**This volume is one of eleven which have been prepared covering the final report of Marshall Space Flight Center investigations of the Saturn V Lunar Logistic System (LLS). This volume presents underlying philosophy and data resulting from an investigation of LLS test requirements and the most effective means of satisfying these requirements. Test parameters and methodology are emphasized along with test facility requirements and availability of government and private facilities. Transportation of large hardware items was studied. Boosters were evaluated for flight testing. Recommendations for flight modes and test ranges are made.**

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LUNAR LOGISTIC SYSTEM

VOLUME VII

TESTING ASPECTS

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AEROBALLISTICS DIVISION

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## LUNAR LOGISTIC SYSTEM VOLUME VII TESTING ASPECTS

By

J. L. Tidd  
B. Guyton  
L. S. Yarbrough

### INTRODUCTION

The purpose of this volume is to present the underlying philosophy and data resulting from an investigation of Lunar Logistic System (LLS) test requirements and the most effective means of satisfying these requirements. No attempt was made to formulate a test plan per se, neither was an attempt made to establish a test schedule in detail. Emphasis was placed on the accurate determination of required test parameters and the methodology of their solution (whether within or beyond the current state of the art, etc.) rather than pursue an individual measurement to its most precise detail. At this stage of the program it was felt that delving into these extreme details would result in precision but without accuracy. No attempt was made to define the required ground tests in detail. Additional emphasis was placed on the determination of what test facilities would be required and then exploring government and private sources to verify if these facilities exist (or are planned for use during the LLS test time frame) or whether they must be provided and funded as an integral part of the LLS program. The problem of transporting these large hardware items (Lunar Braking Stage, L-I, and Lunar Landing Stage, L-II) from the manufacturer to the test area, or to test launch or launch area was studied; and although it is an admittedly difficult question, there are a number of options available for solving the problem. In the area of flight testing, many test boosters were evaluated on the basis of performance, availability, complexity of booster,

complexity of count-down, cost, etc., and recommendations for the different flight modes are presented. Some typical trajectories have been computed to show the wide range of test conditions that can be obtained with the recommended test vehicles. Similarly, the available test ranges were evaluated and recommendations made for different flight modes.

Acknowledgement is given to the excellent support given by Lloyd Stone and Hollis Arban of the Aeroballistics Test Flight and Computations Section for the determination of the many test trajectories which were investigated during this study. Also, acknowledgement is made to Mrs. Martha Ingram for editorial assistance in the preparation of this volume.

#### A. GENERAL

The relatively small number of logistic vehicles required, combined with their high mission importance, makes it essential that the development test plan be simple, inexpensive and thorough. Simplicity is necessary; highly sophisticated plans often provide data which are compromised by the complexity of the test plan itself. The need for economy, of course, requires no explanation, and the need for a thorough test program is closely related to economy; the high hardware investment requires that LLS tests provide as much confidence as possible prior to actual test flight of the vehicle.

Therefore, the test program envisioned for the LLS utilizes every known technique available for evaluating the performance, capability, reliability and qualification of the vehicle. Although the program presented here is for a two-stage craft designed for the Saturn V, the basic concepts are applicable, with little or no change, to a craft designed for the Saturn IB. If a single-stage craft utilizing a Saturn IB or Saturn V is required in the future, the preceding statement also holds true. Regardless of configuration, the same general parameters and sequence of events prevail and must be evaluated.

#### B. ASSUMPTIONS

The testing aspects are based in part upon the following assumptions:

1. Research and development for launch vehicles is completed under launch vehicle programs.

2. Saturn IB and Saturn V launches may be used on a non-interference basis for component qualification and for later LLS flight tests.

3. Development of LLS subsystems (except engines) requires, essentially, only the adaption of existing hardware to the configuration, environments and flight profile.

4. Development of the LLS engines is independent of, but coincident with, LLS development. The engines should require, essentially, only LLS system testing.

5. The Saturn guidance system, supplemented by optical and electromagnetic radiating sensors, will be adequate for the Lunar Logistic mission. It will have been properly tested prior to the LLS program and will require essentially only system testing under the LLS program.

6. No development program for test boosters will be required. Minor modification to available hardware will provide proper and adequate test boosters.

7. Hardware for flight testing is available when required.

### C. TEST CLASSIFICATION

For convenience, the tests considered for this program have been categorized as ground tests and flight tests (Fig. 1).

1. Ground Tests. In general, ground tests comprise all those tests prior to an actual flight of the LLS. Individual component testing, operational testing, environmental testing, pre-flight checks, as well as the usual design verification tests encountered in a development program, are ground tests. It is expected that stringent quality control and reliability control techniques will be utilized throughout, and that the items delivered will be of the highest quality that the manufacturer is capable of producing. The quality control processes will ensure that the item delivered is as designed -- the remaining tests are intended to prove that the design is adequate for the mission.

The unique operating environment of the LLS, as well as some of the performance characteristics of the vehicle, places a premium upon the type facilities required for the program. However, examination of nationwide

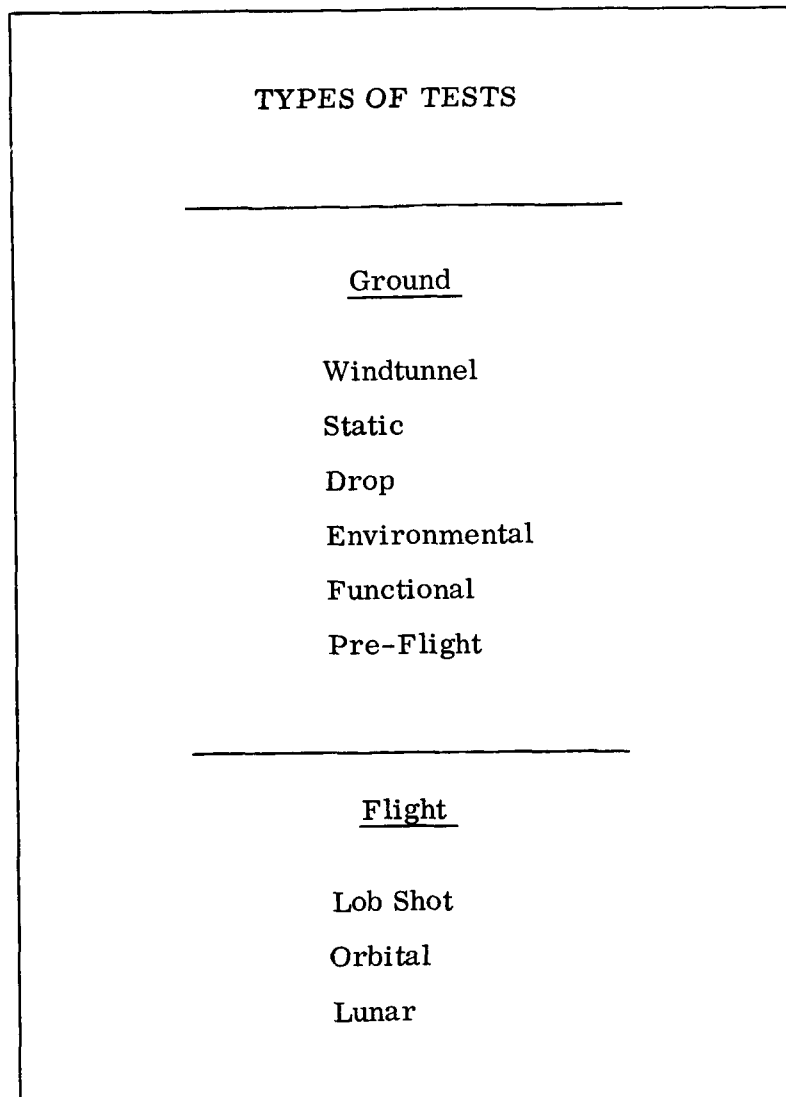


FIGURE 1. TYPES OF TESTS

operational and environmental test facilities (Fig. 2) required for the program, shows that all the necessary equipment and facilities, with the possible exception of an astronics flight simulator, are either available or will be available by the time the program progresses to the point that such facilities are needed. No distinction is made at this time between government-owned facilities and contractor-owned facilities. Generally, though, the larger facilities are or will be government owned.

Obviously, arrangements for the use of the several facilities must be made early in the program. This is necessary to insure that no undue delay is permitted.

One foreseeable, though not insoluble, problem which may influence the project and the test program (both in the choice of ground test locations and in the scheduling of flight tests) is that of transportation. The large size of the LLS precludes normal transportation methods. If accessibility to any of the inland or seaboard waterways exists, barge transportation will suffice. Also, one company has adapted a commercial transport airplane for carrying bulky cargo of this type. Another company has proposed transporting large space vehicles by blimp. Finally, and depending upon geographic locations, it may be possible to transport the LLS overland by truck during slack travel hours. Much is being done in this area at present and it appears that significant progress will be evident soon. For this reason no singular recommendation will be made here.

2. Flight Tests. No amount of ground testing can replace an actual flight in which true operational and environmental conditions are encountered. Ideally, a number of test flights should be made following the actual earth-moon trajectory; yet in the case of the LLS, with its necessary and presently rather rigorous energy requirements, only a Saturn class boost vehicle is capable of placing the LLS into a lunar flight trajectory. The availability of such boosters is low and the cost very high; therefore, it is essential that some means of circumventing these factors be considered.

To provide such a means, the objectives of a flight test were isolated and studied.

These objectives were finally reduced to seven (Fig. 3). Only the lunar flight can actually meet all seven of these objectives. However, a lob shot (i. e., ballistic sub-orbital flight) and an earth-orbital flight will each satisfy five of

FACILITIES			
<u>Test</u>	<u>Equipment</u>	<u>Available</u>	<u>New Facility Cost</u>
Structures	Drop Tower	Yes	
Astrionics	Vacuum Tank	Yes	
	Flight Simulator	No	\$300, 000
Tanks	Particle Gun	Yes	
	Vacuum Tank	Yes	
	Test Stand	Yes	
Flow System	Vacuum Tank	Yes	
Pressure System	Vacuum Tank	Yes	
	Test Stand	Yes	
Engines	Test Stand	Yes	
	Pump Stand	Yes	
Landing Gear	Tether Equipment	Yes	
System	Test Stand	Yes	
	Dynamic Test	Yes	
	Facility		

FIGURE 2. FACILITIES

FLIGHT TESTS			
	<u>Lob Shot</u>	<u>Earth Orbit</u>	<u>Lunar</u>
Structural Integrity	X	X	X
Landing Gear Performance	0	0	X
Astrionics	X	X	X
Engine Performance	X	X	X
Separation	X	X	X
Hover	X	0	X
Space Soak (Life Test)	0	X	X

FIGURE 3. FLIGHT TESTS

the seven objectives (Fig. 3). The major consideration in choosing between lob shots and earth-orbital flights is the cost per test objective. The booster vehicle is the largest single cost factor and it has been determined that Saturn V flight tests are over three times as expensive as Saturn IB flight tests. Saturn IB flight tests, in turn, are over ten times as costly as lob shots launched by smaller boosters. Further, smaller boosters can be made available much earlier than Saturns for LLS test flights.

#### D. TEST BOOSTER EVALUATION

On the basis of required performance characteristics, costs, and booster capability, the boosters and their missions are recommended as follows:

Lob Shots - Little Joe II

Earth-Orbital Flight - Saturn IB

Lunar Flight - Saturn V

The Little Joe II (Fig. 4) is being produced for Apollo tests and is readily adaptable for LLS tests. Even with the stringent aerodynamic requirements imposed by a 260-inch diameter LLS body (Fig. 5), evaluation of its performance shows that almost ten minutes of free-flight time can be obtained. This time is sufficient to meet lob-shot test objectives.

Further, if the recommended test booster is chosen, lob-shot testing can begin as soon as flight hardware is fabricated, whereas the use of earth-orbital or lunar-transit flights dictates a delay until a suitable Saturn class booster is available.

Thus, lob shots are recommended as the prime means of determining LLS performance. At least one earth-orbital flight should be used to verify life expectancies and anticipated space hazards, while, as will be indicated later, the lunar flight will be the final test of the program.

#### E. FLIGHT TEST ASPECTS

1. Lob-Shot Profile. For the purposes of this investigation, a vehicle configuration as shown in Figure 5 was chosen with the performance characteristics of the staging in lunar orbit (SLO) configuration of the LLS. (It should

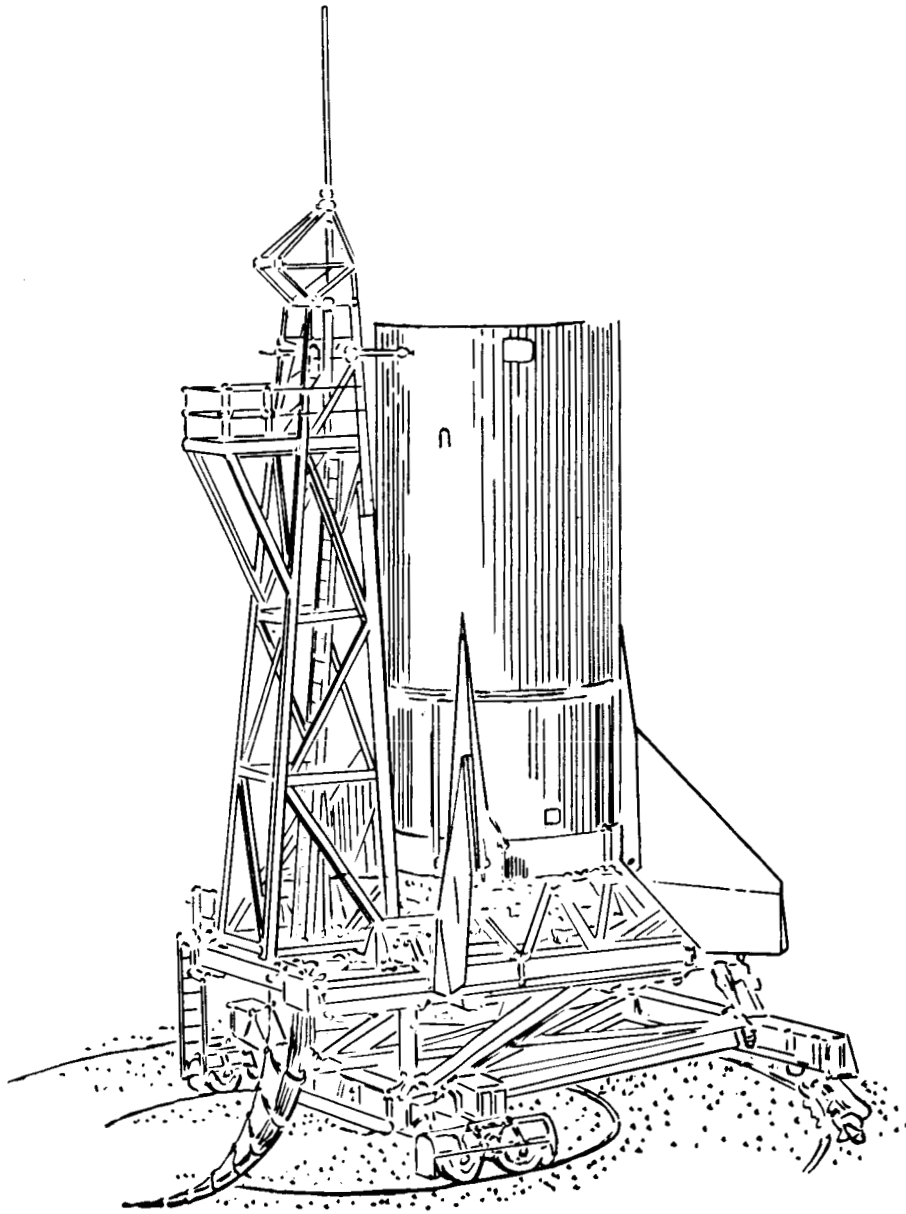
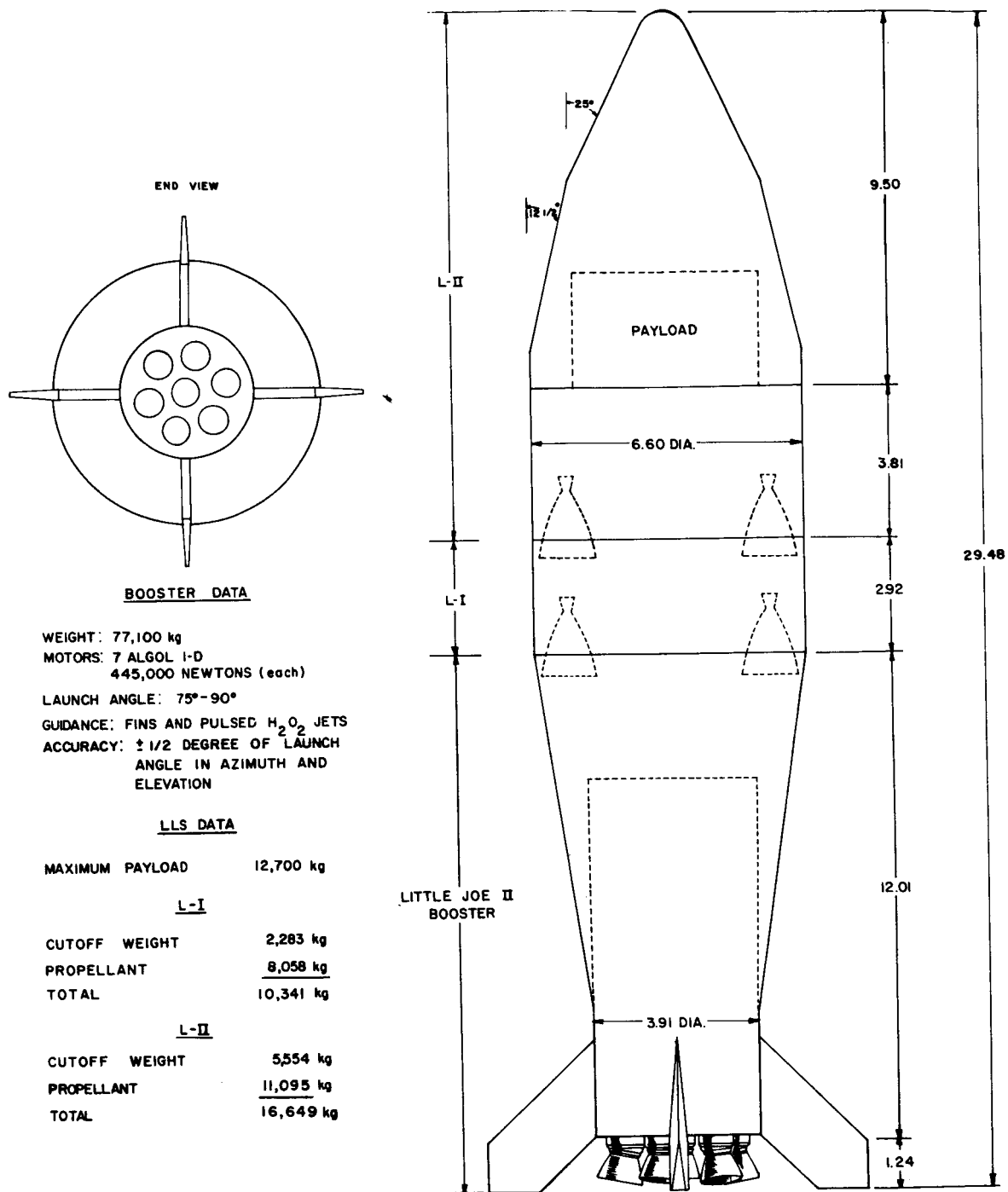


FIGURE 4. LITTLE JOE II AND LAUNCHER



NOTE: ALL DIMENSIONS IN METERS

FIGURE 5. LITTLE JOE II AND LLS

be noted, however, that most other configurations and performance characteristics associated with Saturn IB or Saturn V lunar cargo carriers will give similar results.) Analyses by MSFC aero- and flight-dynamicists indicate that this test mission is easily within the capability of the present Little Joe II.

Figure 6 portrays the cross section of a typical lob shot. Its parameters were taken at random from within the governing envelope and do not represent the best or worst conditions. This figure and the following narrative description are furnished to show the wealth of flight data to be obtained from a lob shot and what a powerful flight test tool is available in the Little Joe II, developed by General Dynamics/Convair for the Apollo test program.

The following data were assumed in the programing and buildup of the "Lob-Shot Profile":

Firing Site	WSMR
Firing Azimuth	North ( $0^\circ \pm 10^\circ$ )
L-I Weight (with propellant)	4,032 kg
L-II Weight (with propellant)	14,987 kg
L-I Burning Time	60 sec
L-II Burning Time	100 sec
Little Joe II Motor Firing Sequence	4-3

The complete vehicle weight is 96,100 kilograms. A launch angle of 85 degrees was arbitrarily chosen. During the first 84 seconds (i.e., during the Little Joe II rocket motor burning time) extensive measurements of shock, acceleration, vibration, structural stresses and bending moments can be made. This is the period of the most severe loading and also of maximum acceleration. However, preliminary calculations indicate that loading will be less than 6800 kilograms per square meter and the acceleration will be less than 32.0 meters per second per second (3.3 "g's"). A velocity of about 1100 meters per second will be attained at burn-out. During this time, also, propellant sloshing effects will be monitored.

For the purposes of this sequence, three seconds will be allowed for separation. At this time, the booster and LLS will be at an altitude of approximately 40 kilometers or, for all practical purposes, out of the sensible

atmosphere. It is anticipated that the separation interfaces will be essentially the same as for the Saturn V and LLS, so that separation dynamics can be monitored and verified.

Beginning at 87 seconds, the braking stage (L-I) engines will be ignited and burn at full thrust for 60 seconds. At the end of this period (about 150 seconds from lift-off) an altitude of approximately 94 kilometers will be attained. During this period, engine performance, pressurization, propellant flow and attitude control functions will be telemetered. The measurements to be made will include flow rates, temperatures, vibrations, pressures, roll rates, and control response times.

Again, at the end of this period, another three seconds will be allowed for separating the L-I from the L-II (including the jettisoning of the nose shroud). The braking stage (L-I) will then be soft-landed by parachute for post-test analysis. This operation will be telemetered. Then, the engines of the landing stage (L-II) will be started and throttled in such a manner that the stage will reach an apex of 185 kilometers at about 326 seconds after lift-off. During this period, the same type measurements will be made as were made for the braking stage.

From apex until approximately 562 seconds, the stage will be attitude controlled in such a manner as to simulate the landing maneuvers to be encountered in the lunar vicinity during a lunar transit flight. Also during this period, terminal guidance equipment (horizon seekers, sun sensors, doppler lander or radar altimeter) will be operated and evaluated. At the end of this period and at an altitude of approximately 76 kilometers, the landing stage will be commanded to simulate a landing. This simulation will end the test and the stage will be soft-landed by parachute for post-test analysis.

Alternatively, the parachute for this stage can be such that it will allow the stage to soft (earth) land under engine power at approximately 1.6 meters per second per second (or 1.0 lunar "g"), with the landing dynamics being monitored.

In the early stages of the program, each stage will be flown separately before a lob shot with two stages is attempted. Also, it is expected that at least one lob shot will be made with the LLS fully loaded, so that the performance dynamics under full load can be verified.

During a lob shot, almost 600 measurements, using two to four RF data links will be made (Fig. 7). These measurements will be converted into digital form before transmission and will be processed directly in real-time (while the flight is in progress) by a computer of the IBM 7090 type. On the basis of the LLS flight performance, the computer will command the vehicle through its programmed maneuvers. In the event of sub-system failures, the computer will immediately go to a pre-programmed alternate test routine and all tests except the failed system will be achieved. The failure and its cause will be pinpointed by measurements so that remedial action may be taken.

Some of the more important results expected are listed in Figure 8. One successful lob shot can provide much data about the performance of the LLS. Present estimates are that five lob shots will be sufficient to completely flight test the system, assuming no catastrophic test failures. In fact, with a program which is more than moderately successful, fewer than this number may suffice.

The preceding profile described can be readily adapted to any other LLS configuration chosen for the Saturn V. The LLS configuration for the Saturn IB also can be adapted with the further advantage that a fully loaded stage may be carried by the Little Joe II.

An infinite number of trajectories can be obtained for test purposes using the Little Joe II booster with various combinations of loading and operating of the L-I and L-II stages. Three typical trajectories have been computed (Figs. 9 through 15). The trajectory (Fig. 9) was obtained by burning the Little Joe II booster for 84 seconds and separating from the LLS during a three-second coast period. At booster separation, the LLS is at an altitude of nearly 40 kilometers, essentially out of the earth's sensible atmosphere. At 87 seconds from launch the two RL-10 engines of the L-I stage ignite and burn for 60 seconds. Operation of the L-I stage is monitored during this period. Earth storables used for mid-course correction during earth-lunar transit can also be tested. At 147 to 150 seconds the L-I cuts off and separation occurs. Testing of the L-II now begins. The L-II coasts for 93 seconds to an apex of 118 kilometers at 240 seconds. The L-II engines ignite and burn for 300 seconds through a hover point at 89 kilometers altitude.

The trajectories (Figs. 10 and 11) are somewhat similar and demonstrate the versatility of the Little Joe II booster and LLS for test flights. The ascending

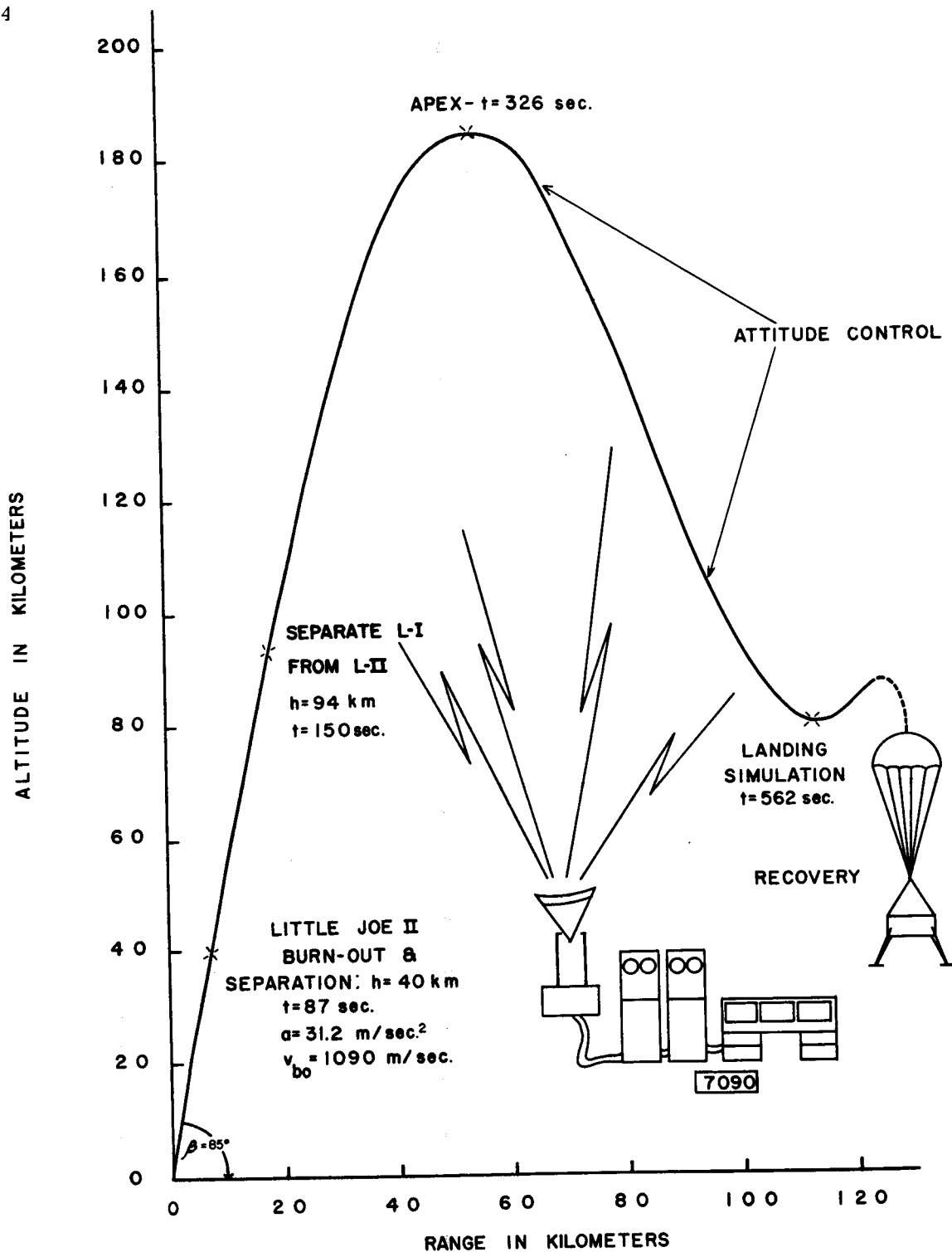


FIGURE 6. LOB-SHOT PROFILE

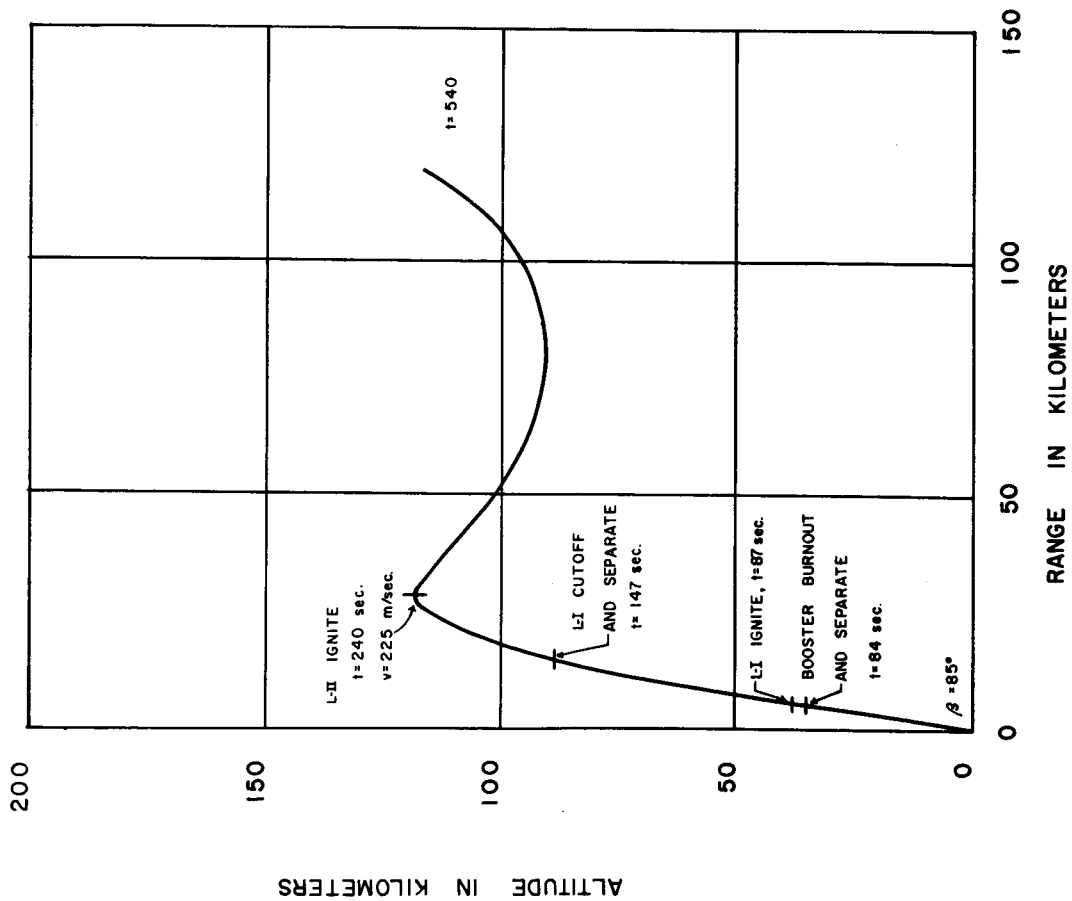
<u>MEASUREMENTS</u>	
Propulsion	120
Astrionics	150
Structures	50
Tanks	50
Fuel Flow	60
Pressurization	20
Homing Guidance Device	75
Miscellaneous	50
Total	575

FIGURE 7. MEASUREMENTS

## LOB-SHOT TEST RESULTS

1. Evaluation and improvement of check-out procedure.
2. Evaluation of horizon seekers, sun sensors, radar altimeter, command system, on board tracking equipment.
3. Separation dynamics of stages and shroud.
4. Engine performance--start, throttleability, shut-down, mid-course correction.
5. Guidance and control - accuracy, response time.
6. Hover dynamics.
7. Pressurization performance - demands, reaction time.
8. Fuel flow - pumping rates, demands, pressures.
9. Flight environment - shock, vibration, acceleration, altitude, temperature.
10. Landing maneuver - attitude control, thrust levels, acceleration, velocities.

FIGURE 8. LOB-SHOT TEST RESULTS



# LITTLE JOE II BOOSTER

WEIGHT 76388 kg  
 BURN 4 ALGOL ID 42 sec  
 BURN 3 ALGOL ID 42 sec  
 SEPARATE BOOSTER 3 sec

## L-I

WEIGHT 6000 kg  
 DRY 2418 kg  
 PROPELLANT 1850 kg  
 EARTH STORABLES 1460 kg  
 TEST EQUIPMENT 272 kg  
 BURN 2 RL-10 ENGINES 60 sec

## L-II

WEIGHT 16213 kg  
 DRY 5700 kg  
 PROPELLANT 9248 kg  
 EARTH STORABLES 452 kg  
 TEST EQUIPMENT 813 kg  
 COAST 93 sec  
 BURN 2 RL-10 ENGINE 300 sec

FIGURE 9. LLS HOVERS AT 89 KILOMETERS

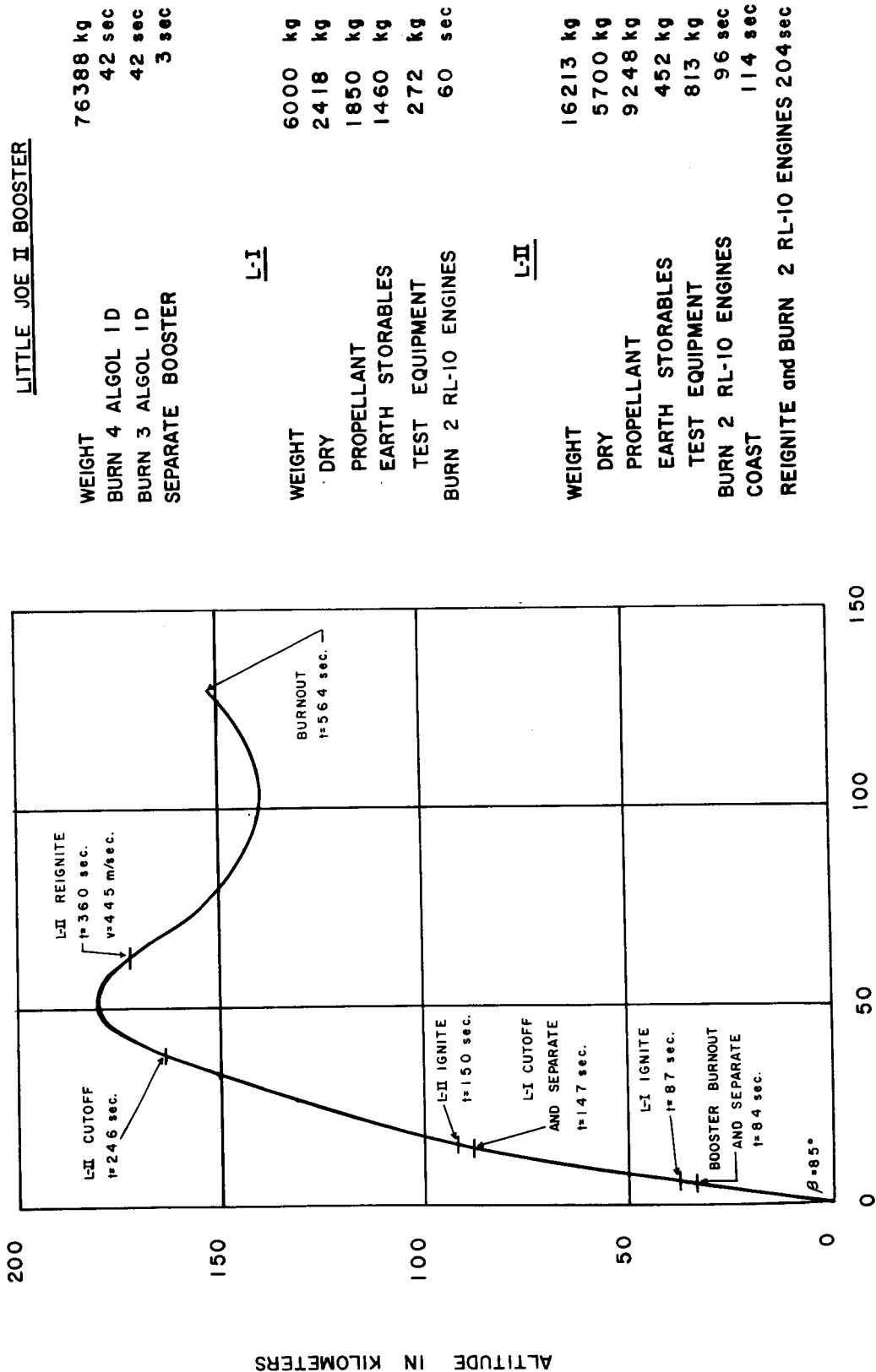
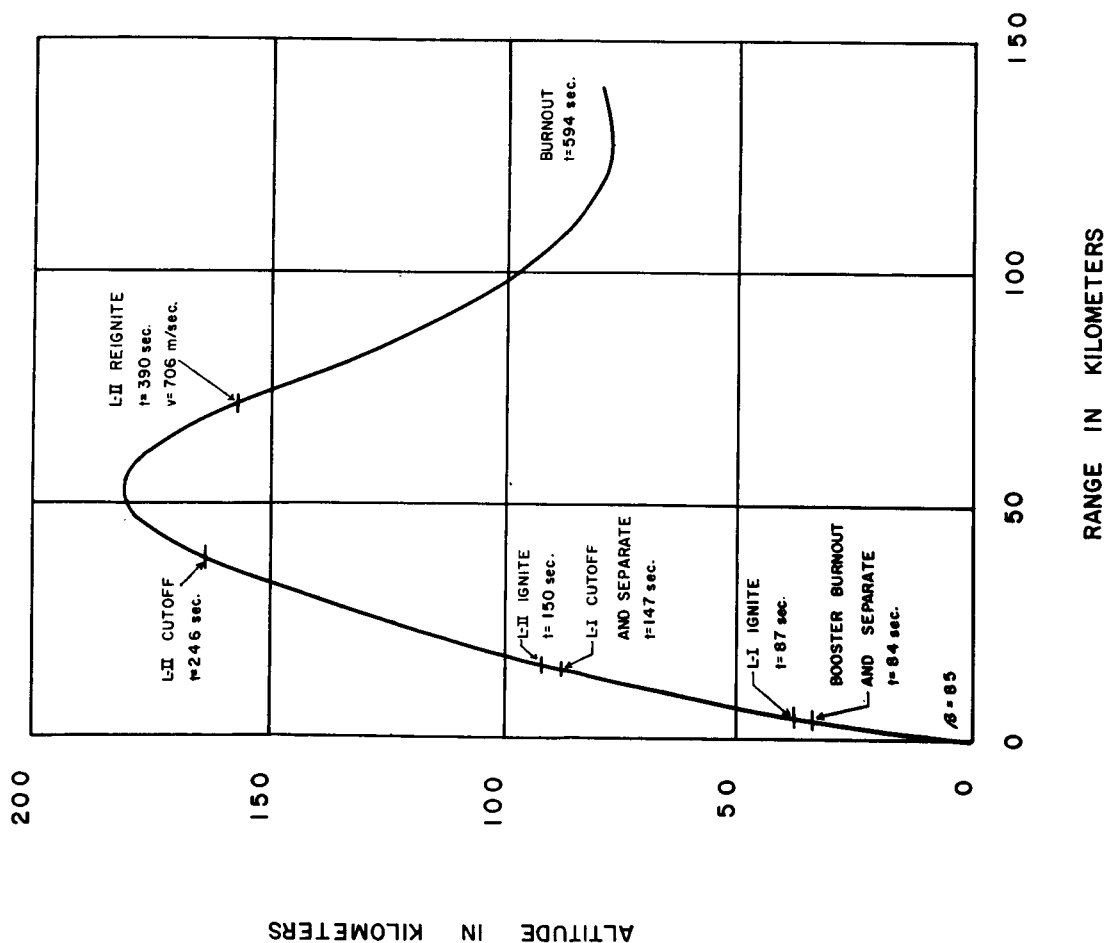


FIGURE 10. LLS HOVERS AT 139 KILOMETERS



### LITTLE JOE II BOOSTER

WEIGHT 76388 kg  
 BURN 4 ALGOL ID 42 sec  
 BURN 3 ALGOL ID 42 sec  
 SEPARATE BOOSTER 3 sec

### L-I

WEIGHT 6000 kg  
 DRY 2418 kg  
 PROPELLANT 1850 kg  
 EARTH STORABLES 1460 kg  
 TEST EQUIPMENT 272 kg  
 BURN 2 RL-10 ENGINES 60 sec

### L-II

WEIGHT 16213 kg  
 DRY 5700 kg  
 PROPELLANT 9248 kg  
 EARTH STORABLES 452 kg  
 TEST EQUIPMENT 813 kg  
 BURN 2 RL-10 ENGINES 96 sec  
 COAST 144 sec  
 REIGNITE and BURN 2 RL-10 ENGINES 204 sec

FIGURE 11. LLS HOVERS AT 77 KILOMETERS

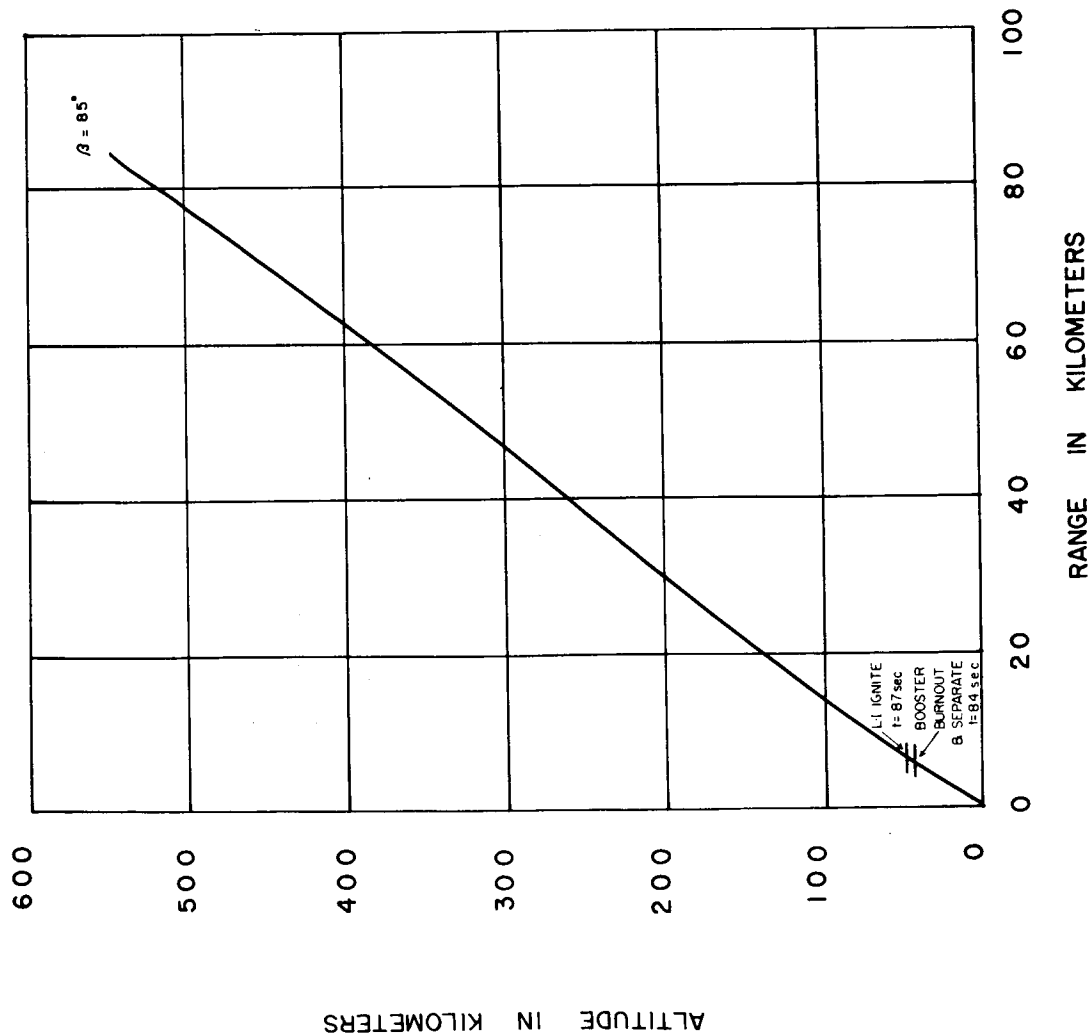
LITTLE JOE II BOOSTER

FIGURE 12. ALTITUDE VERSUS RANGE FOR L-I

WEIGHT

BURN 4 ALGOL ID

76388 kg

42 sec

BURN 3 ALGOL ID

42 sec

SEPARATE BOOSTER

3 sec

L-I

WEIGHT

12195 kg

DRY

2418 kg

PROPELLANT

7820 kg

EARTH STORABLES

1460 kg

TEST EQUIPMENT

497 kg

BURN 2 RL-10 ENGINES

254 sec

ISP

440 sec

MASS FLOW RATE

30.8 kg/sec

# LITTLE JOE II BOOSTER

WEIGHT 76388 kg  
 BURN 4 ALGOL 1 D 42 sec  
 BURN 3 ALGOL 1 D 42 sec  
 SEPARATE BOOSTER 3 sec

## L-I

WEIGHT 12195 kg  
 DRY 2418 kg  
 PROPELLANT 7820 kg  
 EARTH STORABLES 1460 kg  
 TEST EQUIPMENT 497 kg  
 BURN 2 RL-10 ENGINES 254 sec  
 ISP 440 sec  
 MASS FLOW RATE 30.8 kg/sec

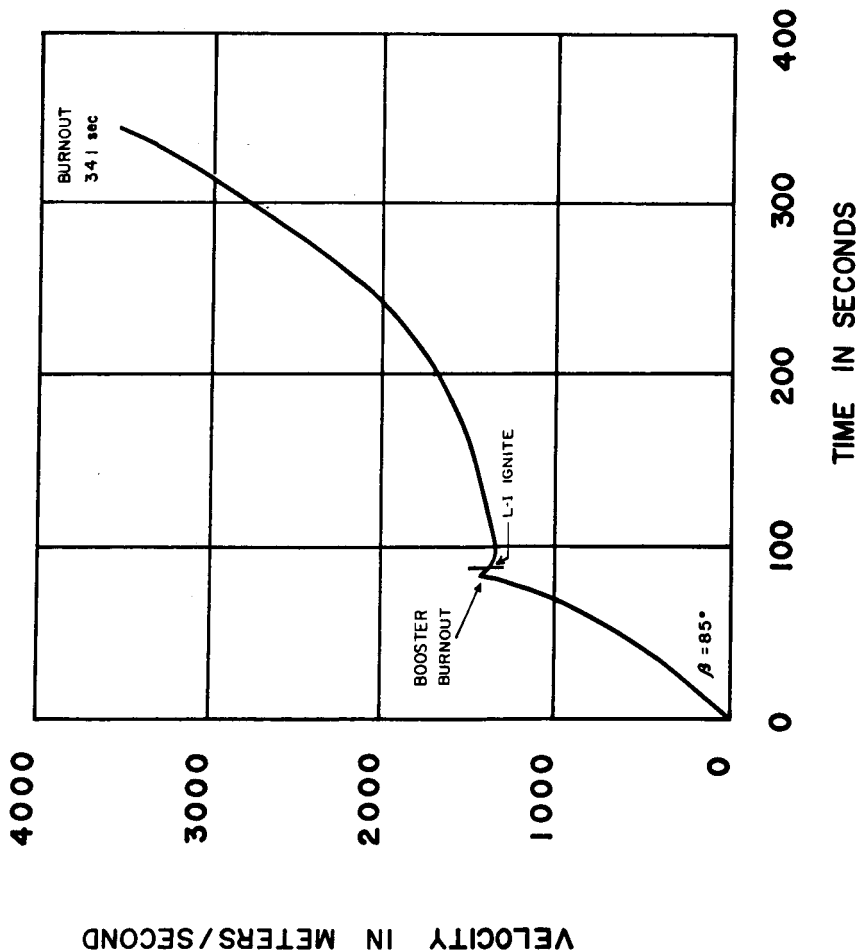


FIGURE 13. VELOCITY VERSUS TIME FOR L-I

LITTLE JOE II BOOSTER

WEIGHT	76388 kg
BURN 4 ALGOL 1 D	42 sec
BURN 3 ALGOL 1 D	42 sec
SEPARATE BOOSTER	3 sec

WEIGHT	16814 kg
DRY	5334 kg
PROPELLANT	10938 kg
TEST EQUIPMENT	542 kg
BURN 2 RL-10 ENGINES	355 sec
ISP	440 sec
MASS FLOW RATE	30.8 kg/sec

L-II

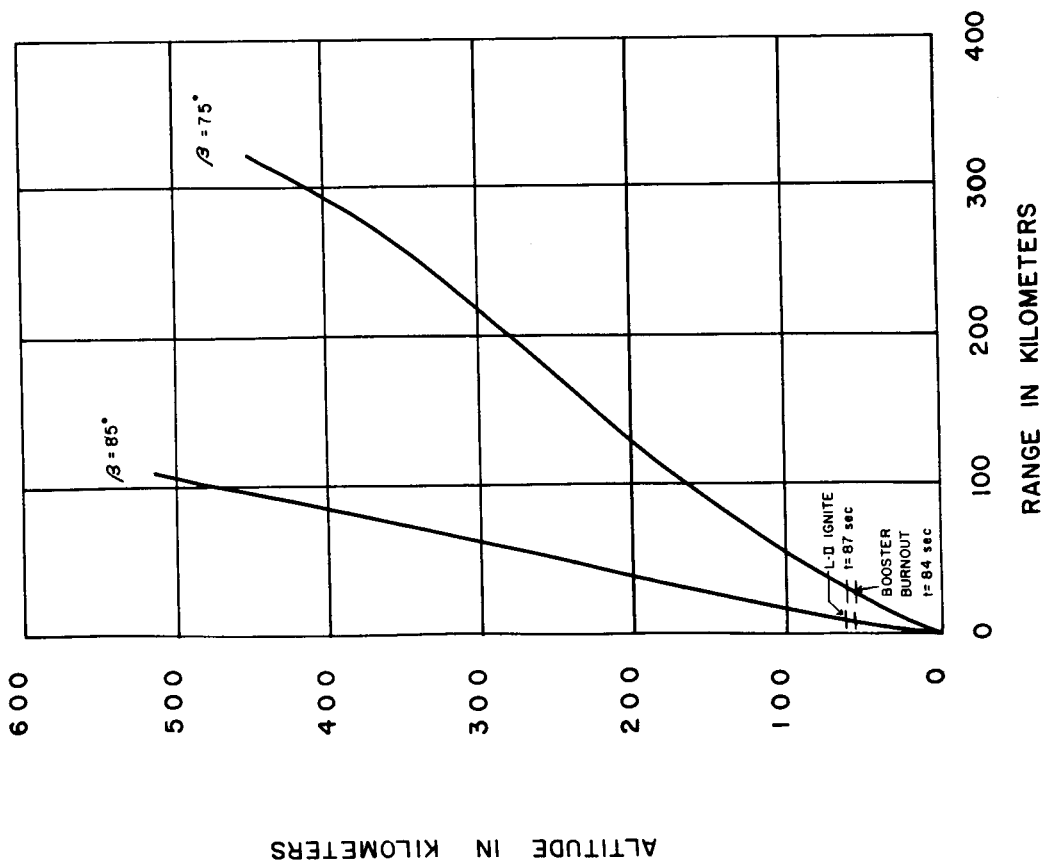


FIGURE 14. ALTITUDE VERSUS RANGE FOR L II

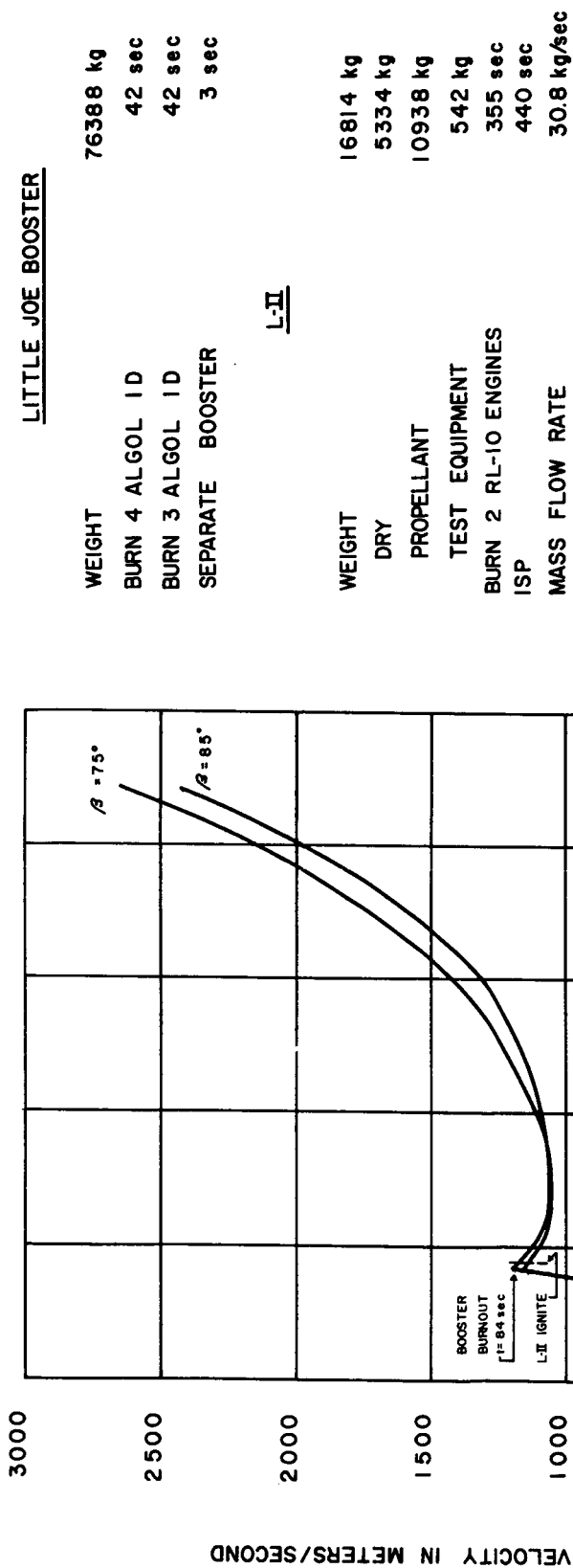


FIGURE 15. VELOCITY VERSUS TIME FOR L-II

portion of both trajectories are identical. On Figure 10 the L-II engines ignite at 360 seconds and give hover capability at 139-kilometer altitude; whereas, on Figure 11 the L-II ignites at 390 seconds and gives hover at 77-kilometer altitude.

Prior to test flights of the complete LLS, testing of the L-I and L-II is needed. Figure 12 shows a trajectory of an arbitrarily loaded L-I launched by a Little Joe II. Some 254 seconds of burning time are available for testing at full thrust; more time would be available for throttled-engine tests. The velocity versus time plot (Fig. 13) indicates a range of velocities available for testing from 1500 to 3500 meters per second.

Computed trajectories for the L-II launched by Little Joe II booster are shown on Figure 14 for a typical loading launched at angles of 75 and 85 degrees from the horizontal. Velocities are shown on Figure 15. Some spread in altitude, range, and velocities is readily available by varying the launch angle.

It should be emphasized that the computed data presented in Figures 9 through 15 were obtained by arbitrarily loading the test vehicles and operating within a time frame to produce desired flight paths. Within the capacity of the propellant loading, any desired trajectory can be obtained for test purposes.

2. Test Ranges. The selection of the test range is almost as important as the type of flight tests selected. Currently there are five possible locations (Fig. 16). Further investigation of range availability and facilities indicates that White Sands Missile Range (WSMR) is the logical choice for lob-shot firings (Fig. 17).

This range, at present, offers the advantage of a relatively uncrowded schedule with space being no problem. Off-range firings can be accommodated, if desired. The instrumentation coverage (Fig. 18) cannot be duplicated at present at any of the other ranges. This is primarily, of course, because of the inland characteristic of this range. At WSMR, electronic, optical, and photographic coverage of the LLS can be obtained from launch to landing. Also, recovery of the LLS is more practical, since it will touchdown on land. As an indication of the type coverage available, present WSMR equipment can determine true velocity to 0.2 meter per second, and attitude to 30 seconds of arc.

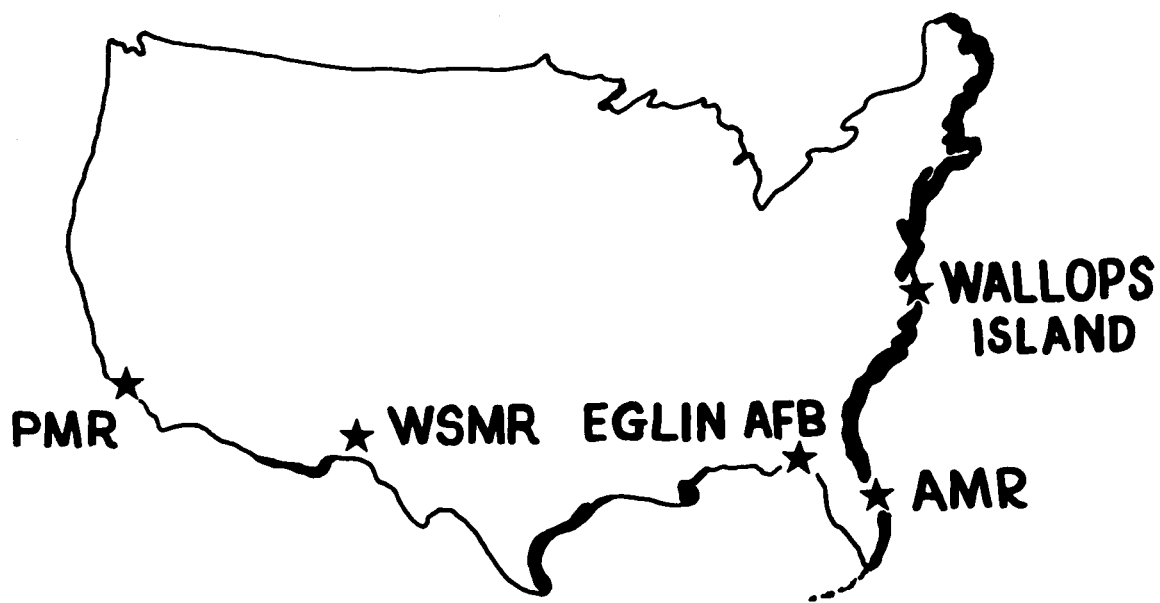


FIGURE 16. RANGE LOCATIONS

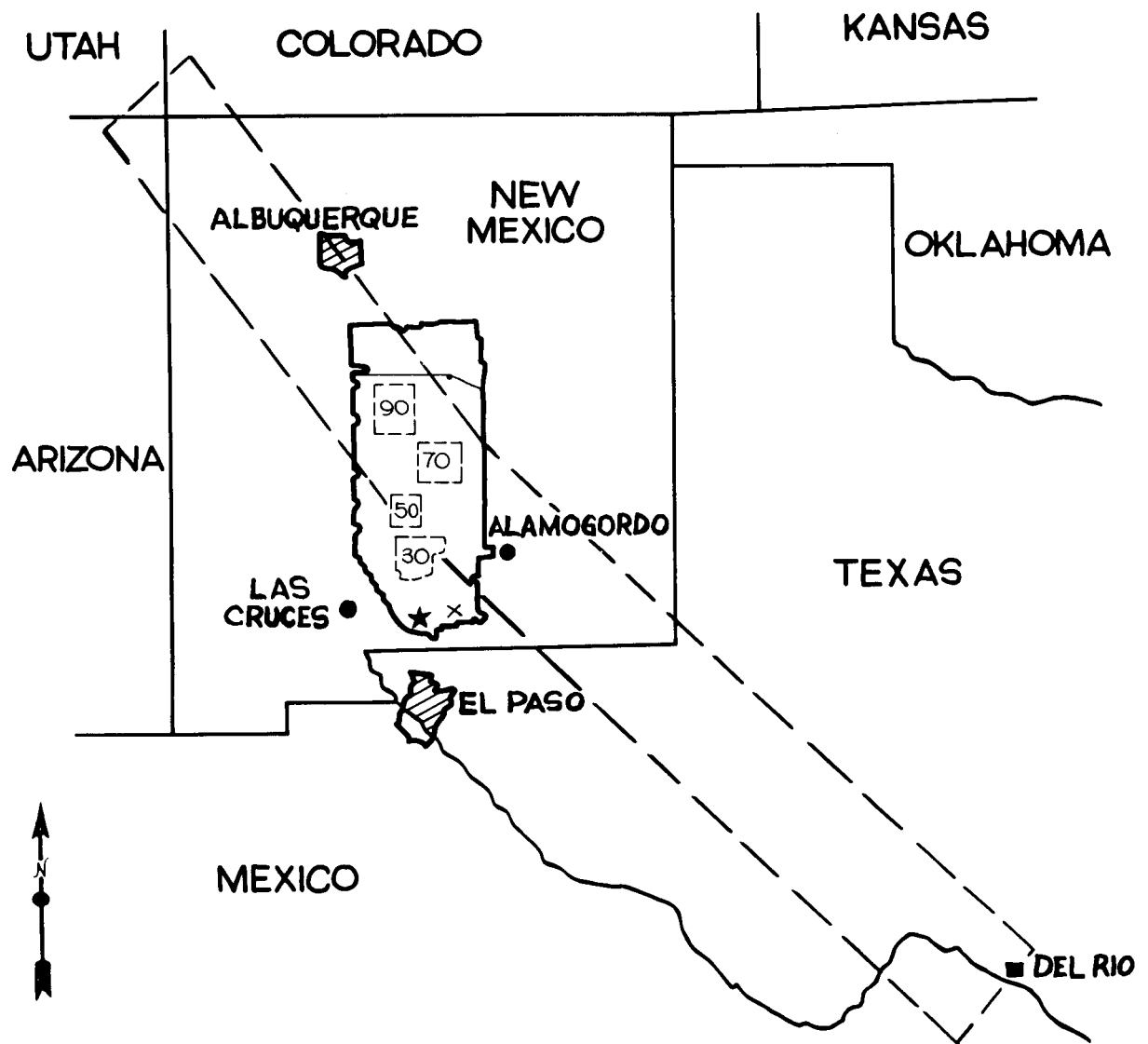


FIGURE 17. WHITE SANDS MISSILE RANGE AND TEST CORRIDORS

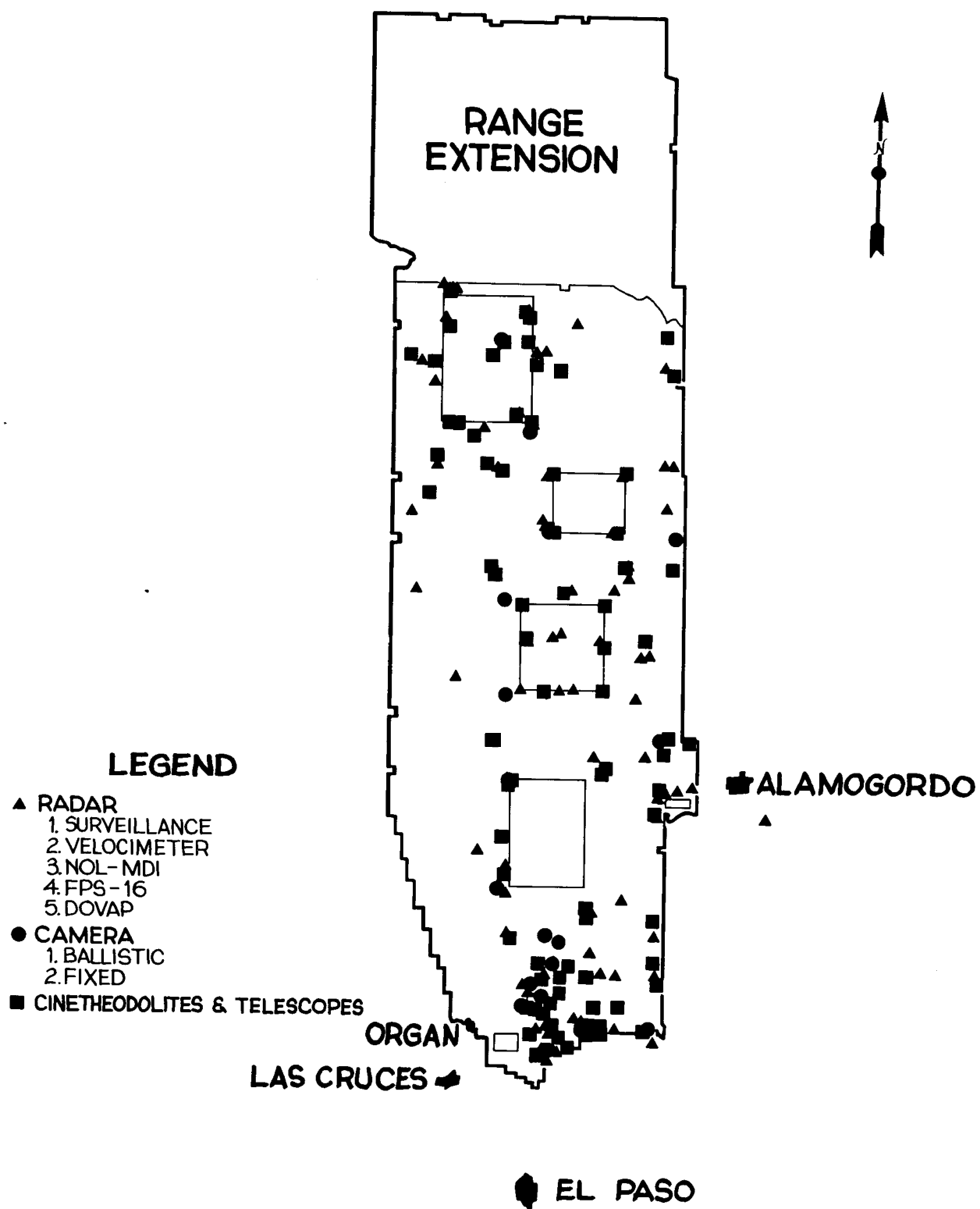


FIGURE 18. WHITE SANDS INSTRUMENTATION COVERAGE

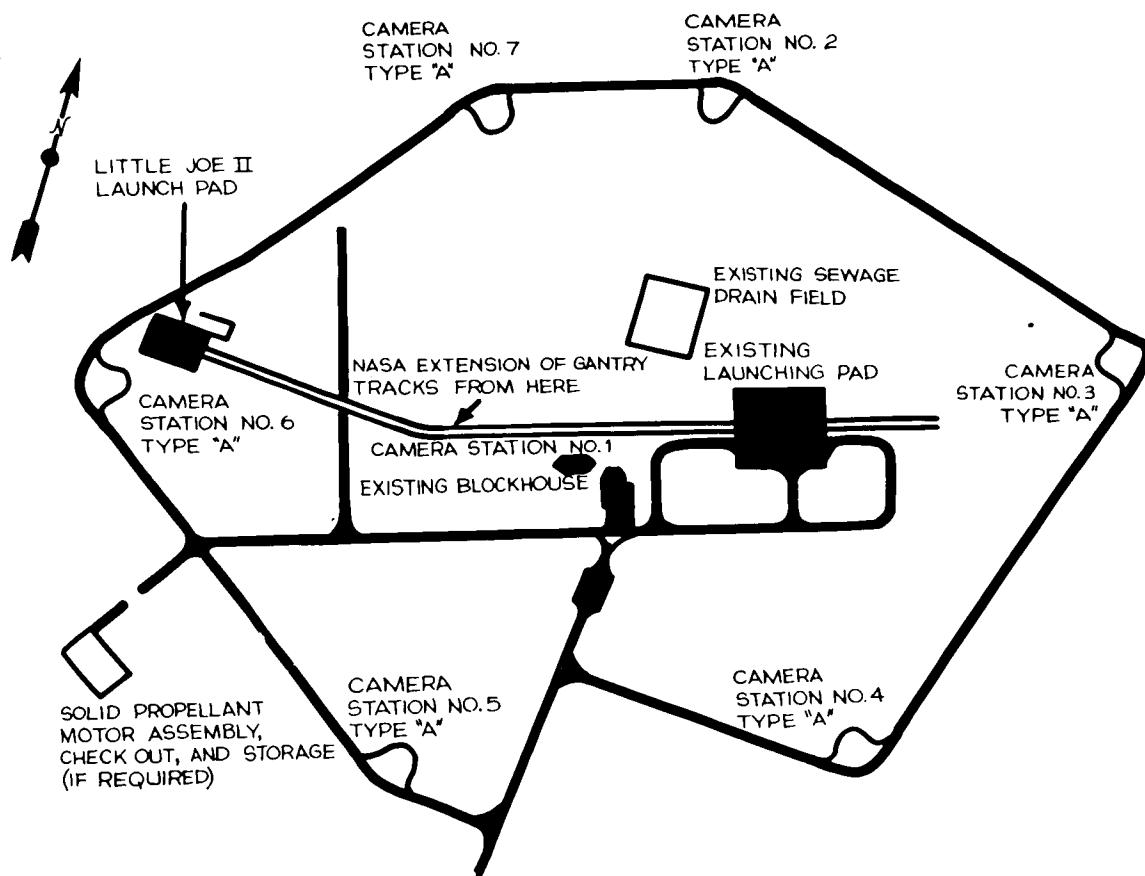


FIGURE 19. WSMR ARMY LAUNCH AREA 3 (REDSTONE)

Additional facilities required for launching at WSMR are minimal. Tracking stations, a blockhouse and a gantry presently exist. An additional tracking station is being built and blockhouse and gantry modifications are being provided by the Apollo program under the direction of the Manned Spacecraft Center, Houston. A new launch pad is being constructed for the Apollo tests (Fig. 19). If the equipment and facilities are further modified for LLS usage, the foreseeable costs are around \$300,000 (Fig. 20). If it becomes necessary to vent hydrogen or oxygen from the LLS while it is on the pad, an additional cost for a gas disposal system must be included. The present gantry modified for use with the Little Joe II and the LLS is shown in Figure 21.

Present Apollo and anticipated LLS schedules indicate that the Apollo flight program from WSMR will be completed prior to the time the facilities will be required for the LLS tests.

Unless launch facilities are readily available at any of the other ranges, the cost of providing new launch facilities might very well be prohibitive. In addition, PMR and AMR have extremely heavy firing schedules for the next few years; these two ranges, Eglin AFB and Wallops Island, also have the disadvantage of being over water, which necessarily limits instrumentation coverage and complicates vehicle recovery.

<u>Existing</u>	<u>Under Construction (For MSC)</u>	<u>Required (For LLS)</u>
Gantry	Gantry Mods	Gantry Mods
Blockhouse	Blockhouse Mods	Blockhouse Mods
Tracking Stations	Tracking Stations	
	Launch Pad	
	Launchers	Launcher Mod
Cost	\$900,000	\$300,000

FIGURE 20. WSMR LAUNCH FACILITIES

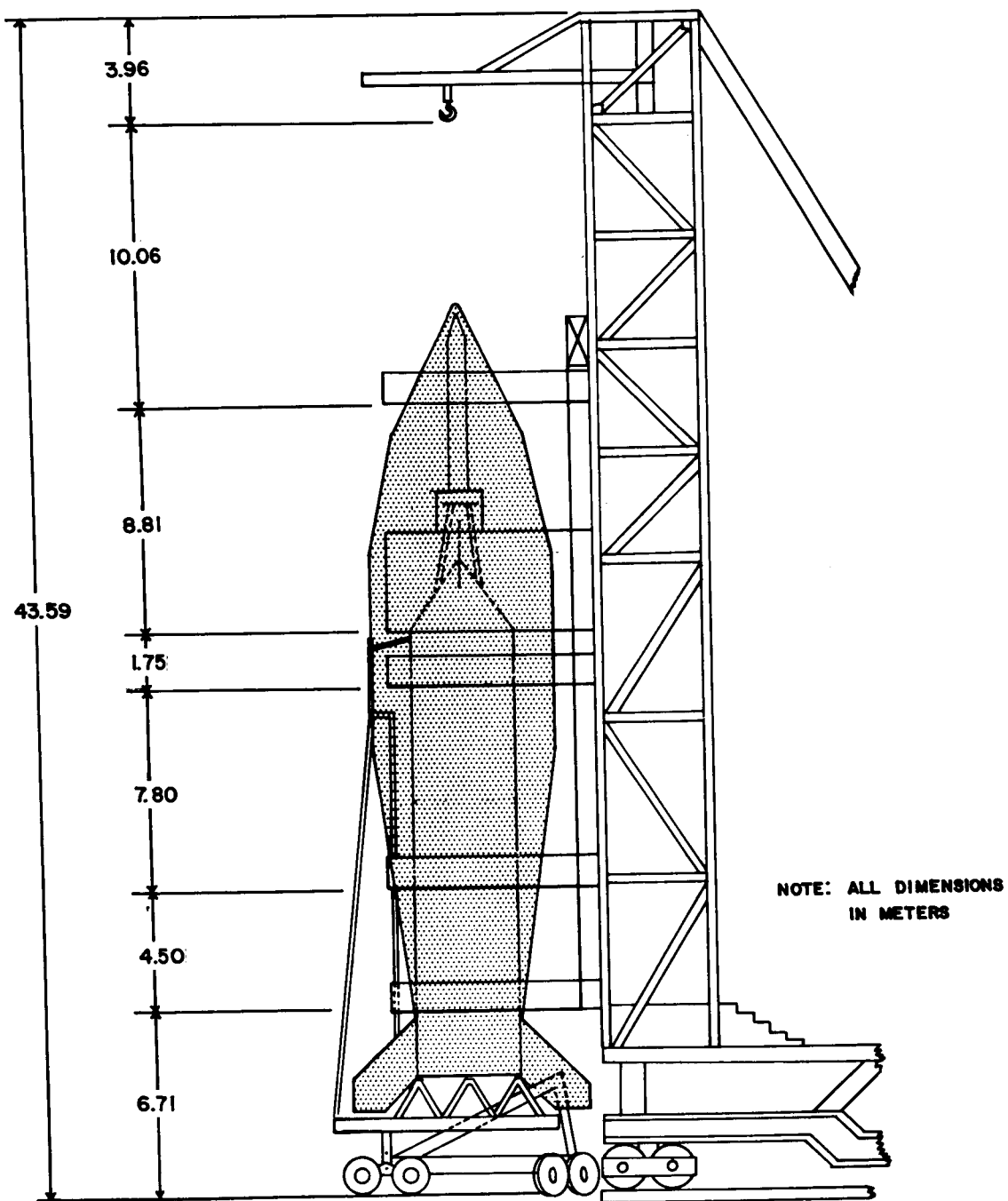


FIGURE 21. WSMR GANTRY SHOWING LLS SUPERIMPOSED  
ON LITTLE JOE II/APOLLO

3. Earth-Orbital Flight. Earth-orbital flights are required to provide data about solar radiation, micrometeorite impingement and life factors (Fig. 22). As in the case of the lob shots, nearly all performance objectives can be met; only landing gear performance and hover cannot be determined. Such a flight requires a Saturn class booster and this in turn limits the test range to AMR. It is anticipated that Saturn R&D firings can be used for this mission.

The lunar transit time is expected to be between 69 and 100 hours. Therefore, it is believed that a minimum of 120 hours (five days) in orbit is required to determine propellant losses and the ability of the LLS to withstand a space environment. If a Saturn IB is used, it can place 14,500 kilograms into a 185-kilometer circular earth orbit. Propellant losses during a five-day orbit are estimated to be less than 500 kilograms out of approximately 8000 kilograms of propellant.

A Saturn V, of course, can place a fully loaded LLS into earth orbit. However, this booster can also place the LLS into a lunar transit and this will provide all the data obtainable from the earth orbit plus the data and experience from a full lunar mission. Thus, it is not realistic to consider the Saturn V for an earth-orbital test unless the orbital test can be as an added feature to another test.

It must be noted here that the cost of obtaining space-soak data will be very expensive. If reliable space-soak data can be obtained from other programs and can be applied with confidence to the LLS, the requirement for an earth-orbital flight of the LLS can probably be eliminated. If, however, such data cannot be obtained and used, then an orbital flight will, as stated previously, provide knowledge of LLS performance under an extended space environment. The earth orbital test flight will also provide a self-check for the Deep Space Instrumentation Facility (DSIF), which is required for tracking and telemetry during the lunar mission.

4. Lunar Flight. The lunar-test flight is the proof of the development program. Additionally, such test flights will attempt to land an operational payload on the moon as a part of the mission. The additional expense and resources required for the cargo are small when compared to the other costs in the program; further, success here will represent an inestimable scientific and program advance.

5. Missions and Requirements. Based on the foregoing, representative mission assignments are shown in Figure 23. These missions assume that lob shots will be used as the primary means of flight testing.

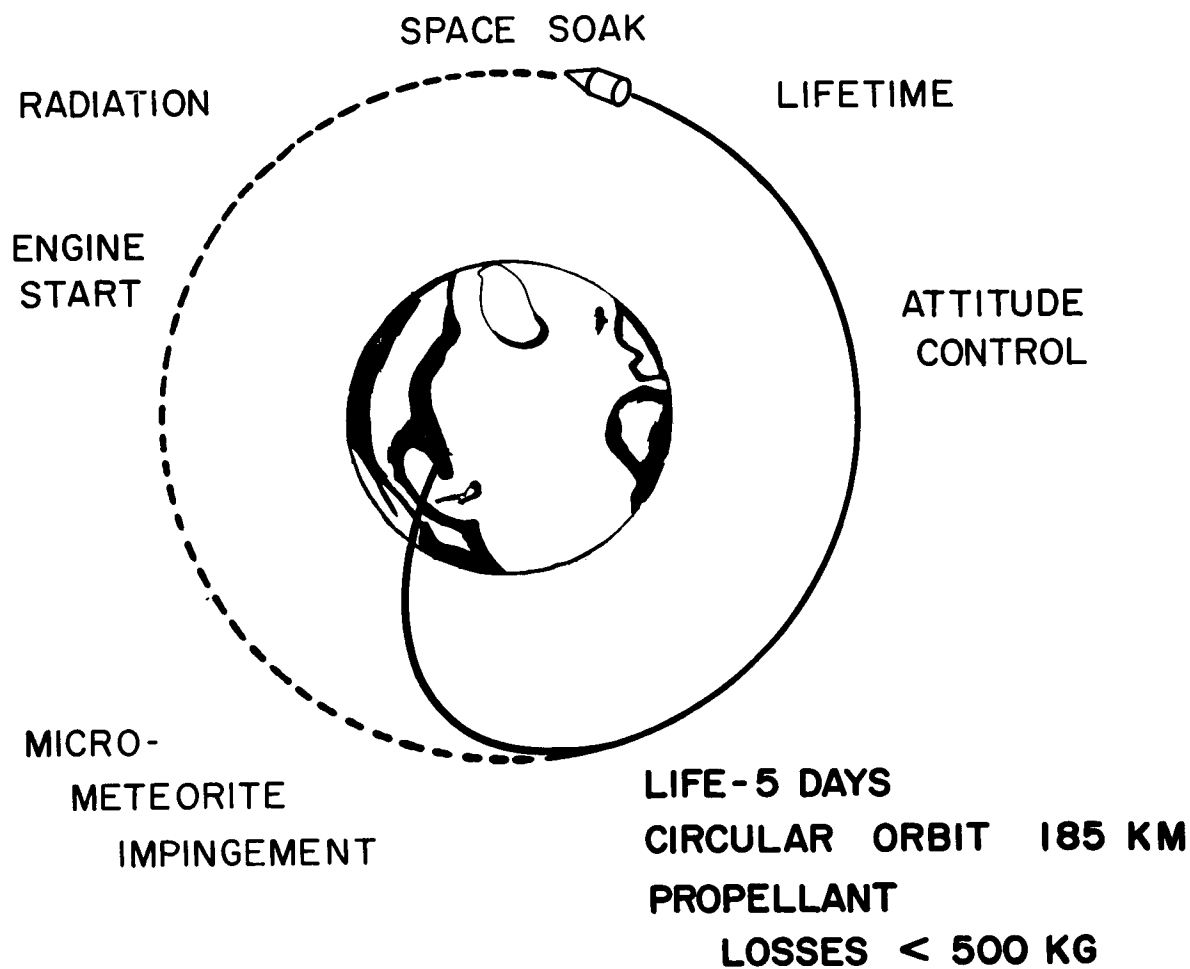


FIGURE 22. EARTH-ORBITAL TEST PROFILE

FLIGHT MISSIONS		
<u>Flight</u>	<u>Payload</u>	<u>Mission</u>
Lob-Shot	L-I	Verify Test Facilities, Separation L-I From Boost Stage, Engine Performance
Lob-Shot	L-II	Verify Flight Dynamics, Attitude Control, Engine Performance
Lob-Shot	L-II	Separation L-II From Boost Stage, Engine Performance, Landing Simulation
Lob-Shot	L-I/L-II	Separation L-II From L-I Engine Performance, Staging, Landing Simulation
Lob-Shot	L-I/L-II	Verify Flight Dynamics, Engine Performance, Staging, Attitude Control, Landing Simulation
Earth Orbital	L-I/L-II	Attitude Control, Space Soak, Life Test, Engine Performance
Earth Orbital	L-I/L-II	Attitude Control, Space Soak, Life Test, Engine Performance
Lunar	L-I/L-II	Lunar Landing (With Usable Cargo)

FIGURE 23. FLIGHT MISSIONS

In order to meet these mission assignments, hardware requirements are summarized in Figure 24. If it is not used during the test program, the "backup" hardware will be reassigned elsewhere in the program.

#### F. TEST ORGANIZATION

If a program with mission assignments as listed above evolves, the usual government-industry team concept would be an appropriate tool for executing the test program. It appears that a liaison office will be required at WSMR at an early date to establish and maintain the necessary close coordination with the range.

#### G. RECOMMENDATIONS

Based on the results of this study, the following are recommended:

1. That lob shots be utilized as a very attractive means of flight-testing the LLS;
2. That a modified Little Joe II be used for lob-shot testing;
3. That WSMR be selected as the site for lob-shot testing;
4. That at least one earth-orbital flight be used for those parameters not evaluated by lob shot and to verify those parameters which are evaluated by lob shots;
5. That any lunar transits which are undertaken be a full system demonstration, since the increased costs and complexity of a lunar landing due to an operational cargo are negligible when compared with the cost of the lunar mission.

	HARDWARE REQUIREMENTS				
	Launch Vehicles			LLS Stages	
	Little Joe II	Saturn IB	Saturn V	L-I	L-II
Test Stages					
Static (W/Engines)				1	1
Dynamic and Structures (Without Engines)				1	1
Test Components				1 Set	1 Set
Flight Stages	5 1 Backup	1 Opera- tional 1 Backup	1 Opera- tional 1 Backup	5 Opera- tional 1 Backup	6 Opera- tional 1 Backup
TOTAL	6	2	2	9	10

FIGURE 24. HARDWARE REQUIREMENTS



APPROVAL

MTP-M-63-1

LUNAR LOGISTIC SYSTEM  
VOLUME VII  
TESTING ASPECTS

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

  
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